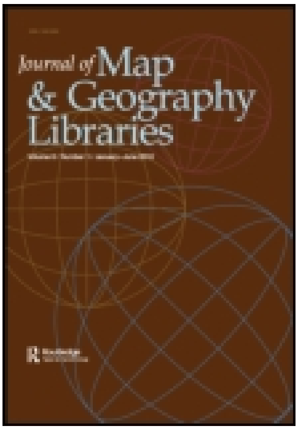

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Digital Curation and the GeoWeb: An Emerging Role for Geographic Information Librarians

Bradley Wade Bishop [a] , Tony H. Grubesic [b] & Sonya Prasertong [c]
[a] University of Tennessee , Knoxville , TN , USA
[b] Drexel University , Philadelphia , PA , USA
[c] University of Kentucky , Lexington , KY , USA
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BRADLEY WADE BISHOP
University of Tennessee, Knoxville, TN, USA
TONY H. GRUBESIC
Drexel University, Philadelphia, PA, USA
SONYA PRASERTONG
University of Kentucky, Lexington, KY, USA

The rise of the GeoWeb and the proliferation of volunteered geographic information (VGI) have permanently changed the volume and types of geospatial data available for consumption. This has simultaneously altered the role of data curation and information provision roles of geographic information librarians (GILs). The purpose of this paper is to provide a succinct history of geospatial data services in libraries and a discussion of current challenges encountered by information professionals with the GeoWeb. The paper concludes with an overview of the importance of incorporating the GeoWeb into future geospatial data curation training.

KEYWORDS *GeoWeb, geographic information librarianship, digital curation training, data curation*

INTRODUCTION

Broadly defined, the GeoWeb refers to a merger between the Web, geospatial technologies, and geographic information (Herring 1994). Inseparable

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Address correspondence to Dr. Bradley Wade Bishop, School of Information Sciences, College of Communication and Information, 451 Communication Bldg., University of Tennessee, Knoxville, TN 37996-0341. E-mail: bbisho13@utk.edu

from the Web 2.0 infrastructure and technology (O'Reilly 2005), which allows users to interact, collaborate, and create content, the GeoWeb functions similarly—as a platform where location-based tools, data. and content can be generated and shared by users (Roche et al. 2011). Although most commonly associated with Web-mapping interfaces such as Google Maps, Bing Maps, and Google Earth, the GeoWeb is much more. Three important points need to be made in this context. First, although Google Earth and similar interfaces are often used as base maps for the GeoWeb, the application programming interfaces that provide tools for manipulating (e.g., editing, updating, enhancing) and visualizing geospatial data (maps and charts) are critical for spatially enabling volunteered geographic information (VGI).[1] Second, the GeoWeb allows one to establish the geographical location of virtually all Web content, ranging from photos to tweets, while simultaneously using data obtained from mobile devices (e.g., smartphones) for providing information on user mobility. Finally, as noted by Roche et al. (2011), VGI is no longer neatly nested within the spheres of leisure and amateurism. Instead, VGI is increasingly being considered for use in more mainstream geospatial data application fields such as emergency response and disaster management, where the ability to accumulate and assess nearly real-time geospatial data are critical for mounting relief efforts.

The growing availability and use of VGI presents significant challenges to the digital curation and information provision roles of geographic information librarians (GILs) (Weimer and Reehling 2007). Rather than relying solely on geographic information provided by government entities such as the U.S. Census Bureau or Department of Transportation), geospatial data and related content are now generated by individuals, often unaffiliated with any formal agency or group. Further, rather than relying on mainstream commercial GIS applications, for example, ArcGIS, the GeoWeb has proliferated across open development platforms that are largely free to the general public. Needless to say, implications regarding data uncertainty, especially related to accuracy, precision, and completeness (Murray and Grubesic 2012), are salient for the GeoWeb and must be acknowledged by the GIL community as the process of managing and providing access to resources within the GeoWeb evolves. The purpose of this paper is to provide an overview of geospatial data services in libraries and a discussion of current challenges associated with the growth of the GeoWeb encountered by information professionals. Within this context, we also provide a succinct review of the rise of the GeoWeb and the proliferation of volunteered geographic information in the physical, social, and information sciences. We conclude with an overview of the importance of the role of geographic information librarians for the future of geospatial data curation and the need for an updated and nimble educational foundation for GILs to support a dynamic geospatial data environment.

BACKGROUND

As noted in the Introduction, with the rise of Web 2.0 and the increasing use of digital technologies, large volumes of digital data are being created. Both academic researchers and professionals in the public and private sectors have explored how this user-generated content should be utilized, and the implications of these emerging forms of data and technology related to copyright, authority, and privacy (Elwood and Leszczynski 2011; Haklay et al. 2008; Kinsley 2010; Zook and Graham 2007). Of particular interest to this community is volunteered geographic information (VGI), the subset of user-generated content that has an overtly geospatial component. Increasingly, users are able to create and interact with geospatial data without the need of formal training. Thus, the GeoWeb is quickly changing the ways in which geospatial data, maps, and geographic knowledge are created, defined, and used. Consider the sheer volume of data that are produced daily through users of platforms such as Twitter, Foursquare, and OpenStreetMap. For example, Foursquare, the application that allows users to share their location on social networking sites, has over 25 million accounts and has processed over 3 billion check-ins as of September 2012 (Foursquare 2012). As of November 2012, OpenStreetMap has over 900,000 active contributors (OSM 2012). Needless to say, these sources, and the GeoWeb more generally, have expanded the possibilities for researchers to engage with geographic information and for many users to engage with maps (Crampton 2009; Haklay et al. 2008).

This growth has serious implications for librarians, who are entrusted with archiving, organizing, and presenting information to their users. Further, librarians who handle the GeoWeb may have a lasting impact on the ways in which historical archives are established and maintained. In the following subsections, we provide a background on how geospatial data have been handled by librarians in the past. The need for reconceptualizing educational foundations for library and information science education with respect to geographic information, including the GeoWeb, is also addressed.

Geospatial Data in Libraries

Librarians have acted as stewards of geographic information at least since Eratosthenes was the chief librarian of the museum in Alexandria (Martin 2005). Unlike other users of geographic information, librarians tend to amass layers of past cartographic materials produced by defunct technologies in their roles as curators. Thus, although a current GIS analyst may need only the most recent data, a digital curator must consider the actions taken to maintain and add value to geospatial data over its lifecycle—well beyond their original purpose.

After the Second World War, academic libraries in the United States played a crucial role in national defense efforts by acquiring and cataloging massive numbers of printed maps, ensuring that the country would never be cartographically unprepared for future conflicts (Murphy 1969). Specifically, in 1942 the Army Map Service (now the National Geospatial-Intelligence Agency) selected forty-five academic libraries to begin acquiring thousands of maps as part of the Federal Depository Library Program, a program that provides government documents "for public use without charge" (Nicoletti 1971; Wilhite 2011). Over time, many academic libraries acquired other maps from the Government Printing Office and some still receive print maps from the Department of the Interior's Minerals Management Service, and Central Intelligence Agency. In addition to government materials, map libraries retain collections of unique (often local) print maps. Because many of these maps are rare or largely unavailable elsewhere, librarians must have the skills to catalog and preserve print cartographic resources until they have resources to make them digitally available (Hansen 2012).

The shift between analog and digital geospatial resources was greatly accelerated by the National Research Council's (1993) request for the development of a spatial data infrastructure and President Clinton's Executive Order 12906 (Clinton 1994), forming the National Spatial Data Infrastructure. In particular, Executive Order 12906 stressed the importance of coordinated development, use, sharing, and dissemination of digital geographic information on a national basis in order "to promote economic development, improve our stewardship of natural resources, and protect the environment" (Clinton 1994). Reductions in the cost of duplicative work was also cited as a motivating factor. This information policy also led to the creation of metadata standards from the Federal Geographic Data Committee (FGDC) and the need for geolibraries to facilitate sharing geographic information (Goodchild 2009). This is critical, because nearly 80 percent of all government data retain geospatial locations as their key element (Boxall 2005). Clearly, the scale and complexity of the National Spatial Data Infrastructure combined with the need to create metadata for its associated catalog produced an important job for librarians. Moreover, with the eruption of digital geospatial information from government sources and private sector mapping agencies, librarians were suddenly required in the 1990s to alter collection development and acquisition plans to include CD-ROMs and other digital media (Larsgaard 1998).

In reaction to this flood of digital geospatial data, the Association of Research Libraries' SPEC Kit 219, *Transforming Libraries 2: Issues and Innovations in Geographic Information Systems*, provided librarians with best practices, including the types of GIS services already offered at different academic libraries (Soete 1997). The association's Geographic Information Systems Literacy Project built upon the first SPEC Kit and found that eighty-nine percent of the seventy-two responding academic libraries surveyed

provided GIS services (Davie et al. 1999). This spawned a number of practice-oriented studies that explained the different GIS-related services developed or found in academic libraries (Abresch et al. 2008; Aufmuth 2006; Donnelly 2010; Houser 2006; Johnston and Jensen 2009; Kowal 2002; Strasser 1998). Geographic information librarianship emerged to facilitate the collection, dissemination, and use of both digital geospatial data and traditional analog cartographic resources, representing an outgrowth of traditional map librarianship (Weimer and Reehling 2006).

GILs quickly found themselves helping users locate digital data over the Internet, build geolibraries of their own digital collections, "metalog" geospatial data to support searching and accessing, manage image processing and GIS software, and so forth (Boxall 2002; Larsgaard 2005). *Metaloging* describes the creating of a record for geospatial data using standards other than International Standard Bibliographic Description or Anglo American Cataloging Rules (Larsgaard 2005). Further, the demand for such services extended beyond academic libraries to archivists and records managers in both private and public agencies that handle geospatial data on a regular basis. For specific examples of related projects, the Library of Congress funded the National Geospatial Digital Archive project to collect, preserve, and provide long-term access to at-risk geospatial data that included more than ten terabytes of geospatial data and imagery (Erwin and Sweetkind-Singer 2009), while the Geospatial Multistate Archive and Preservation Partnership (GeoMAPP) collected snapshots of geospatial data that was often at risk of being overwritten by updates and changes to real-time geospatial data (Morris 2009). In turn, similar partnerships are beginning to emerge between academic libraries and government agencies in the digital curation of geospatial data that required more information professionals with the GIL skillset (Hoover 2012). Not surprisingly, library and information science education did not react with curriculum additions or changes covering these skills as quickly as the emergence of the large-scale projects and extensive changes to these types of jobs (Mandel and Weimer 2010).

GIL Education

In response to the growing demand for GIS-skilled librarians and in an attempt to avoid uncoordinated training efforts, the American Library Association's Map and Geospatial Information Round Table (MAGIRT) Education Committee defined a set of core competencies required to perform GIL (MAGERT 2008). The core competencies covered skill sets related to three types of GILs—map, GIS, and cataloging/metadata—over six broad areas (general cartographic competencies, collection development, collection maintenance and organization, reference and instruction, metaloging, and technological infrastructure). More recently, the Laura Bush 21st Century

Librarian Program of the Institute of Museum and Library Services (IMLS) awarded funds to Drexel University for the Geographic Information Librarianship (GIL) project to bolster the digital curation of resources created by an array of geo-location tools in library and information science education.

The curriculum development plan for the IMLS GIL project included a survey of practicing GIS and map librarians, archivists, and other information professionals working with geospatial data to validate the core competencies established by MAGIRT. The survey was designed to weigh the importance of listed knowledge, skills, and abilities from their real-world library experience to inform curriculum development. This survey validation approach has been used by a variety of other professions such as teaching, nursing, and law to inform curricula with empirical data from actual practice (Raymond 2005). Of note, despite the value of these survey findings for the creation of new GIL curriculum, the core competencies from 2008 did not explicitly mention how to handle GeoWeb data because of its ephemerality and novelty. Perhaps for similar reasons, the University Consortium for Geographic Information Science's Body of Knowledge (BoK) also lacks specific coverage of user-generated content, how this content should be utilized, and the implications of these emerging forms of data and technology. The BoK provides geography educators with knowledge areas, units, topics, and learning objectives that are "applicable across the undergraduate, graduate, and postbaccalaurate/professional sectors of GIS&T education infrastructure" (DiBiase and University Consortium 2006). Still, as geospatial technologies rapidly evolve and the variety and number of users grows, the 2006 BoK requires expansion (Prager 2012). Specifically, the BoK has been criticized for containing mostly learning objectives for lower cognitive skills (DeMers 2009).

Given this curricular framework—and while the MAGIRT core competencies focus on higher cognitive skills (mostly knowledge-based)—what is lacking is a discussion of a routine set of skills and abilities required for GILs to operate on a daily basis. In an effort to fill this gap, this paper will offer suggested skills and abilities that are missing in both the MAGIRT core competencies and the BoK and that are required to effectively curate the GeoWeb. This paper addresses the following research questions related to curriculum development in the context of increased user-generated content:

1. What are the roles of GILs in digital curation and information provision of the GeoWeb?
2. What are the knowledge, skills, and abilities related to the GeoWeb for GILs?
3. What are the implications for GILs in practice as a result of the GeoWeb?

Addressing these questions requires speculation beyond the survey validation of the 2008 MAGIRT core competencies or a review of the learning objectives in the 2006 BoK. In order to develop timely and relevant courses in GIL in response to geospatial data created by collaboration, participation, and nonexpert authorship in the GeoWeb, we will offer potential emergent roles here.

THE GEOWEB AND CORE COMPETENCIES FOR GILS

Although the existing MAGIRT core competencies are missing several important facets with respect to volunteered geographic information, and the GeoWeb more generally, the core competencies did provide a useful framework for organizing this discussion and addressing pertinent research questions. For example, the general cartographic competencies remain largely unchanged by the new geospatial technologies, and the importance of spatial literacy, datums, projections, coordinate systems, and related cartographic skills necessary in GIL education will not be rehashed. That said, the lack of fixity in the GeoWeb complicates rigid definitions of what constitutes a map, as well as the ways in which authority and expertise are afforded, but those issues have been covered in great detail in other works (Blatt 2012).

This paper will present the potential roles for GILs as each relates to the five broad areas of the core competencies:

Collection development
Collection maintenance and organization
Metaloging
Reference and instruction
Technological infrastructure

Collection Development

Collection development in library science includes purchasing access to material as well as the decision process for developing collections. Deciding which electronic resources are to be made available to patrons is challenging, given their dynamic nature, as are issues of cost, legitimacy, and authority. As far as geospatial data are concerned, governments have historically collected large amounts of these data, but various government policies have historically dictated availability (Rhind 1999).

The U.S. government's focus on utilizing information technologies to share geospatial data increased with the passing of the E-Government Act of 2002 (E-gov) (Tang and Selwood 2005). In fact, the act specifically called for "Internet service delivery for more accessible, responsive, and

citizen-centered government" (Tang and Selwood 34). As a result of these federal mandates, librarians received less physical media, and E-gov collection development began to include activities such as creating guides of hyperlinks to various E-gov sites and, in some instances, downloading relevant data. Today, many geospatial data sets are available through Geo.data.gov, but it is unclear if there could be any organized collection development approach to incorporating these sites inasmuch as the available data sets are ever-changing.

From a strategic perspective on allocating human resources, increased availability of federal and state government electronic data, and a reduced need to retain versions in both print and electronic formats, librarians may find advantages in staking a claim on campus and offering to host multimedia and other digital assets created by local GIS users and to collect fewer versions of data available on the Web. For example, by acting as a geospatial data repository for student and faculty data, librarians provide a service for constituencies that otherwise would perform data discovery at the start of each project or act as their own data curators. Embedded librarians could take part in teaching, learning, and research enterprises at their institutions or in their local regions and have a more central role in assisting patrons (e.g., faculty, students and staff) through the identification of the most popular geospatial data used and add value by performing these types of services.

The growing use of geographic information also suggests that the GeoWeb is necessarily encouraging libraries to revisit their collection development policies and decide what their roles will be in the future of GIS and geospatial data. The knowledge, skills, and abilities outlined for collection development and records appraisal in archiving from the MAGIRT core competencies include strategies used to obtain different types of maps, imagery, and geospatial data. Not surprisingly, this requires a more nuanced understanding of the kinds of resources available from commercial and nonprofit publishers, their avenues of distribution, and new trends in the production and delivery of geospatial data. Based on this knowledge, GILs need the ability to write a collection development plan that considers the rules of selection and deselection of federal and state government documents, copyright considerations, and sustainability of any geospatial data the library commits to collect. When local, state, and federal agencies make their data accessible via geoportals, libraries may no longer need to duplicate the storage and maintenance of that data, but libraries can still collect versions in the event the data or the geoportal becomes unavailable.

Regardless of the delivery method, it is clear that GILs need to have a concrete plan for collection and dissemination in a rapidly expanding and dynamic geospatial data environment. Moreover, data accessibility is complicated by issues of ownership within the GeoWeb. Again, although much of the information contributed to, and created within, online environments is generated by the public, the platforms these data are being submitted to are

privately held, and ownership of the content differs between organizations (e.g., Google, Twitter). As a result, the information a user provides or shares on these platforms is subject to the policies that have been defined by the sites. This is a serious concern for collecting, maintaining, and disseminating information from the GeoWeb.

Collection Maintenance and Organization

Once items are obtained by an organization as a result of collection efforts and associated policies, several important tasks are required for effective digital curation. The knowledge, skills, and abilities related to GIL for collection maintenance and organization have revolved around cartographic resources produced by vendors and government agencies. These items include map scanning and digitization processes, standards, and copyright limitations and materials handling and preservation methods of both print and digital cartographic items such as encapsulation. Despite the vast differences in various cartographic resources, much of the work pertaining to authoritative resources can be used as a foundation for organizing the user-generated GeoWeb.

The migration from purchasing materials toward curating user-generated cartographic resources creates several new considerations for librarians. For example, the use of print Sanborn Map Company maps illustrates several important parallels for curation of the GeoWeb. Sanborn maps have served as the definitive resource for determining the degree of fire hazard and associated liability in urbanized areas. Today print Sanborn maps present a valuable primary resource for historians, urban planners, preservationists, and many others beyond their original purpose. When active, Sanborn was aggressively extending map coverage to additional cities and providing revisions to existing maps in the form of paste-on correction slips. For the original users, these labels were necessary for accuracy and were pasted over existing maps during the update process. Unfortunately, these paste-on corrections and subsequent updates occurred without any considerations beyond the immediate original purposes. The value of items beyond their original purposes is not predictable, and many GeoWeb users, like the Sanborn creators, concern themselves with only the most recent version. The archivist's or librarian's role remains to preserve and does not assume the future purposes of data by historians or other researchers.

GILs foster the preservation of many digital collections, but deciding what to preserve, if anything, of the GeoWeb has little precedent. The GeoMAPP project however, provides a toolkit for developing a geoarchiving business plan to establish, sustain, and extend an archival program that advances the long-term preservation of a state's valuable geospatial assets. There is no doubt that similar work needs to be considered for the GeoWeb. Without a plan for archiving these data, it is highly likely that they will be

lost. Although the future value of the GeoWeb to users is unpredictable and many institutions with limited human resources will not be able to collect any user-generated data, these geospatial data are not useless. They have been used to save lives in Haiti earthquake relief and other large disasters, and the exploration of who will retain these data is worth a discussion with information professionals from libraries and archives present (Zook et al. 2010).

In fact, librarians and other information professionals have created GeoWeb items to increase the public exposure of collections and services by digitizing and presenting their print map collections online (Lycan et al. 2012). To showcase their cartographic resources, librarians have digitized collections and made them available via Google Earth. For example, the entire Hotchkiss Map Collection of Confederate Army Maps is available online from the Library of Congress. Similarly, the New York Public Library provides a tool for digitally aligning historical maps from their collection to match present-day maps. See http://maps.nypl.org/warper for more details. Once again, it is important to acknowledge that although this vastly increases the usability and exposure of the NYPL collection, once the maps are digitally rectified and their content is uploaded to Google, ownership and associated authority issues become salient.

Metaloging

Up to this point in the paper, many of the roles discussed for GILs assume that the geospatial data being collected, archived, or maintained have adequate metadata. By definition, *metadata* is "information that describes the content, quality, condition, origin, and other characteristics of data or other pieces of information" (Metadata 2006). Metadata are usually tied to or included with the primary resource and are critical to the discovery, assessment, use, and reuse of geospatial data. For example, data collected in a particular cartographic projection cannot be accurately used in a different projection. Further, if reprojection is possible, the initial projection must be known to effect an accurate change.

Related to metadata is the process of *metaloging*. The purpose of metaloging is to make digital items available for use in an efficient, effective way by adding metadata to geospatial data (Larsgaard 2005). Specifically, a surrogate of the actual geospatial data is called a record and each record contains searchable metadata for an item.

Both metadata and metaloging have been at the forefront of geospatial data preservation and use since 1994, when the FGDC published its first document on metadata standards—Content Standard for Digital Geospatial Metadata. The FGDC continues to work with the American National Standards Institute (www.ansi.org), the International Organization for Standards

(www.iso.org), and individual agencies at all levels of government to implement standards pertaining to geospatial data. The benefit of developing strong metadata and associated standards is that geospatial data can be efficiently shared among multiple user groups. For example, the success of projects like Geospatial One-Stop (www.geodata.gov), requires that participants provide metadata that meets the FGDC's basic requirements, including information on themes, scales of use, guidelines, and datasets (FGDC 1997).

Currently, the GeoWeb and VGI do not adhere to FGDC guidelines, nor do many vendors and data producers, as metadata has been the primary challenge, even with authorized producers. Needless to say, without an adequate description of how data were collected and updated, user-generated data sets may not be useful for many purposes. Specifically, without the added value of metadata, geospatial data are of little use beyond the persons or agencies that originally created the data. For instance, keywords and contextual tagging from users enable others to locate the items, but not at the FGDC level that informs users how that data could and should be used. Missing authorship, crowdsourced authorship, unstructured data collection, and lack of authority present challenges for completing metadata records from VGI with minimal description. It is also important to remember that for more traditional cartographic materials, GILs are required to have an understanding of theory and practice of descriptive metaloging, which includes identifying the title, scale, projections, coordinate systems, and determining the authorized form of personal and corporate names of authors and uniform titles. There is no doubt that these same standards would greatly enhance the usability of data from the GeoWeb or VGI sources. The core competencies suggest that GILs should also understand the theory and practice of metadata schemes (chiefly FGDC and Dublin Core, and be able to create and provide GIS and other metadata for institutional repositories and digital libraries.

Reference and Instruction

The knowledge, skills, and abilities listed by the MAGIRT core competencies to accomplish reference and instruction include knowledge of key GIS resources for data and software support, GIS products and companies, and GIS tutorials and training courses available for users. Users may also need help with accessing and using aerial photography and satellite imagery via the GeoWeb. The strategies for discovering digital geospatial resources for use in GIS, performing basic spatial and geoprocessing activities, and developing and delivering introductory GIS workshops are just a few examples of the skills that GILs may need. These basic skills can be enhanced with knowledge of the process of map production and reproduction, and the roles of map publishers, distributors, cartographers, and other contributors to the GeoWeb or more traditional geospatial outlets.

As information providers, GILs will need an ability to answer questions related to geospatial data and instruct others how to find geographic information. Although these are two different tasks in practice, reference and instruction are combined in this discussion and in library and information science education because most instruction in library and archives relates to teaching users the information literacy skills to answer their own future reference questions. In instruction and reference, GILs will need to be able to explain basic cartographic competencies to users such as scale, resolution, projection, and geodesy. GILs may also be asked to create guides or provide hands-on assistance to help users locate geospatial data. In academic settings, training sessions for both users and other library staff could cover anything from basic mapmaking skills to spatial analysis.

Finally, there will be many opportunities for GILs to observe and study the information seeking behavior of users attempting to locate geographic information, as well as usability of GeoWeb applications. GILs will need to maintain a current understanding of the GeoWeb and any changes to it because as subject area specialists, it is assumed (and expected) that they will be able to provide direct guidance to users.

Technological Infrastructure

Whereas reference and instruction duties focus on connecting users with information and teaching them how to locate geographic information on their own, the core competencies for GILs related to technological infrastructure are specific to issues that users have related to geospatial technologies. These skills and abilities relate to the broader role of GILs as technologists. For example, the 2008 core competencies list the ability to perform initial troubleshooting for software issues, to evaluate and install supporting GIS software tools, and to unzip utilities, download, and utilize GPS data. Other knowledge listed by MAGIRT includes computer programming and Web services related to GIS (e.g., Fusion Tables), the creation of scripts for batch processing, data ingestion, Web services, digital library creation and integration, and other geoprocessing applications. Obviously, this is an extremely comprehensive and detailed list of skills, but most are necessary in today's increasingly complex geospatial data environment.

That said, perhaps the most critical skills for GILs are the simple ones, such as helping patrons organize data in a spreadsheet prior to geocoding or converting shapefiles to KML (http://www.zonums.com/shp2kml.html). These basic technical skills relate to all geographic information professionals' jobs. GILs should be able to teach users how to perform these basic tasks. Although the technological infrastructure of the GeoWeb is outside the scope of what librarians should likely know, a basic familiarity with its terminology and its working environment is required.

Beyond the basics, it is important to acknowledge that a vision of synchronous interoperability between many geodatabases utilizes dynamic Web 2.0 features. Prior to the introduction of GeoWeb technologies, geographic information systems often had their own image formats, maps, and database schemes (de Carvalho et al. 2007). As a result, sharing geospatial data was complicated due to a lack of interoperability between different organizations or between individuals within the same organization. In response to this issue, the Open Geospatial Consortium (http://www.opengeospatial.org/) created standards that enabled more streamlined sharing of geospatial data, for example, Geographic Markup Language (GML), Web Feature Service (WFS), and Scalable Vector Graphics (SVG) (Peng 2005). Given the diversity of needs among users, GILs need to be familiar with these standards and basic interoperability issues.

For example, GML is an XML language for encoding geospatial data's metadata that allows users to define feature-based relationships between different geographic databases, regardless of the network arrangement or geospatial data format (Lake and Farley 2007). WFS allows GML to be queried, which enables remote access and subsequent manipulation of geodatabases (Peng 2005). WFS allows database users to subscribe or link to other geodatabases regardless of the underlying database platform (Lake and Farley). Through SVG, geospatial data can appear on browsers and users can query and manipulate that data remotely. Like all information professionals working in GIS, GILs must continually educate themselves on these rapidly advancing technologies and be aware of how to troubleshoot access issues when they occur.

CONCLUSION

Curation of the GeoWeb's importance grows with the increase in VGI, the mainstream use of VGI by government agencies and researchers, and the emergence of application programming interfaces (APIs) that enable manipulation and visualization of VGI resulting in even more information objects generated. Science has become more collaborative and data-intensive and, as a result, researchers are faced with data management needs requiring assistance. For example, the National Science Foundation directives now require formal data management plans, and it is likely that more funding agencies will follow the foundation's new standards (U.S. National Science Foundation 2010).

Given the recent growth of the GeoWeb and its associated data and use, information professionals are increasingly being asked to provide support for geospatial information and related applications. This is an important development for librarians and information professionals for several reasons. First, the results of a recent survey suggest that one third of all academic libraries are planning to offer research data services (RDS) during the next

two years (Tenopir et al. 2012). There is no doubt that will include RDS for geospatial data. Therefore, the implications for geographic information librarianship resulting from the GeoWeb include the creation of a retooled workforce with the knowledge, skills, and abilities to curate geospatial data and enhance its distribution and use. In the digital curator roles associated with GIL, librarians will need to create data management plans, participate in data description (i.e., metaloging), and create preservation strategies. GILs will also need to assist with data discovery and create guides to lead users to available geospatial data in the information provider role.

To provide the knowledge, skills, and abilities to navigate an increasingly complex and dynamic geospatial data environment, LIS education must be updated and professional considerations should be made on how to address the issues raised in this paper concerning the GeoWeb. Professional development and training in this area is not likely part of the curriculum in traditional geography programs, but it could be. That said, RDS and data curation education are already strengths of several iSchools (www.ischools.org) and traditional library science programs. More focus and institutional capacity needs to be built in the area of geospatial data broadly, and more specifically, VGI. The lack of knowledgeable workers in GIS who create and manage metadata and digitally curate geospatial data leads to more work for all researchers through the duplication of data collections and analyses. A new generation of trained GILs will be better prepared to deal with the moving target of the GeoWeb's geospatial data infrastructure as well as improve access to all geospatial data, enhance research efficiency, data accessibility and analysis of real-world problems.

NOTE

1. Volunteered geographic information refers to the use of tools for creating, assembling, and disseminating geographic data provided voluntarily by individuals (Goodchild 2007).

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